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Abstract

The purpose of this project is to provide an easy to manufacture solution to sampling material from dry bulk tankers. A device was developed using basic design requirements. Once a design was created a CAD design was drawn to illustrate and prototype the device. This prototype was placed under rigorous testing to determine effectiveness. The end result provides a dry bulk sampling device for plant workers and/or truck drivers to sample the material in their tankers and send to the laboratory when unloading at a facility.

Introduction

Dry bulk material such as cement products are transported nationwide to various facilities. Many of these facilities are ready-mix concrete plants, which receive these products by means of tanker trucks. Dry bulk products are tested periodically in accordance with several different American Standards of Testing and Materials (ASTM) methods before it leaves the mill. Each test takes place before storage of the material in silos and the material remains inside the silo until it is loaded for shipping. Tankers are loaded with material from silos and deliver the product to the plant. The customer has no knowledge of the quality of the material deliver unless a sample is gathered and tested. If tests are not performed the questionable product could be of low quality, high quality, or anywhere in between and used by these facilities, which could be a costly problem for the customer. Determining the performance capabilities of the material by sampling the material in the tanker as it arrives at the facility would provide insight into the usefulness of the product.

Problem

Sampling a tanker requires at least two people to climb the ladder on the side or back of the truck to open one of the three hatches located on the top center of the tank. This is a very dangerous position for a person due to the slick condition of the truck, elevation, and lack of support rails. In addition the hatch is located at foot level that requires a person to kneel down. These truck conditions could lead to a fatal slip and fall off the side of the tanker. The Mining Safety and Health Administration (MSHA) have been involved and investigated several of these accidents. This risk has forced many companies to disallow drivers and workers from mounting the tankers. Inside the tank, the dry material was pressurized and has settled into a compact solid surface, so sampling the material from the discharge port requires the use of the plant vacuum system, which is much too powerful to obtain small samples. A lightweight, compact, and strong apparatus that can be attached to the discharge port, vacuum hose, and collect the sample into variable size containers is required.

Development

The development process addressed the necessary issues mentioned above. There are two locations on a tanker, which allow access to the material. The three manholes on the top of the tanker and the discharge pipeline on the rear of the vehicle are the only access points to the material inside the tank. The three manholes on the top of the tank are accessible by climbing to the top of the tank, Figure 1.

Figure 1. Heil Cementer tanker trailer.

This access point is located nearly 12' above ground and does not have suitable safe access. The tanker discharge pipeline is located at the rear of the truck approximately 4' off the ground, Figure 2. The pipeline is 3" diameter aluminum and mounted on the rear framework of the truck.

Figure 2. Heil Cementer tanker rear view.

The vacuum system used to discharge material can operate at a maximum pressure of 20 PSI, although recommended operation is between 12 to 15 PSI.

Changing the discharge pipeline allows manipulation of the product flow and a safer environment for the sampler. Aluminum or PVC pipes are lightweight and strong materials that can be attached to the tanker truck's pipeline and the facility's hose to allow sampling.

Requirements

The tanker truck pipeline is a 3" diameter aluminum pipe with an airtight clamp fitting attachment. The facility's vacuum hose has the matching attachment thus connecting the two. This vacuum hose is only used for loading cement, ash, and slag material into the silos. Therefore, the device must not interfere with the existing connections. The hose is constructed of lightweight rubber material which allows the truck driver to handle the hose with ease. When the sampling device is attached to the hose it must not contribute more than ten pounds. The device must be easy to construct with permanently sealed connections. The device must have two exit ports, one for sampling and the second for main flow into the plant silo. The cement, ash, or slag materials are finely ground particles that create dust clouds when moved in mass. To address the dust situation, the sampling device must have a rubber section at the sample opening to reduce clouding of material. The device must also allow for maximum product flow when sampling is not necessary. An adjustable valve is needed to allow sampling and to refrain from sampling.

Design

The device design originates from a simple straight pipeline from the tanker. The device attaches to the tanker pipeline section and provides a 45^o secondary exit opening for the material. The image below illustrates the connected system, Figure 3.

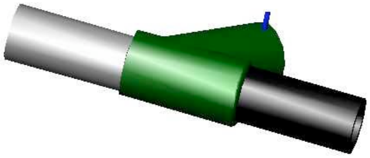

Figure 3. Sample shunt design.

The gray pipeline in the image is the tanker pipeline. The dark gray pipeline is the connection to the vacuum hose of the plant. The green section is the 45^o y-shaped design to collect the sample. In the image below, Figure 4, the blue piece is the sample collector.

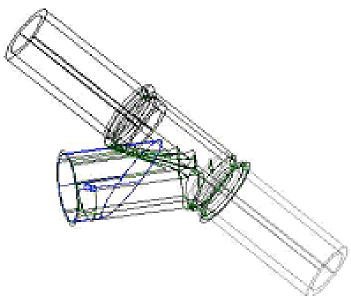

Figure 4. Wire frame schematic.

The collector is the design feature that allows material to pass into the secondary exit without disturbing the main flow. This feature can be moved into and out of the main flow path of the material. For large samples the collector can be inserted into the flow at the maximum depth, Figure 5. For smaller samples the collector can be inserted into the flow at a minimal depth.

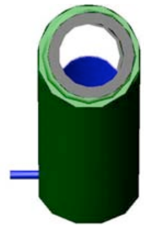

Figure 5. Collector's maximum depth.

The design phase concludes by compiling the requirements and design solutions into a prototype.

Prototype

The prototype was developed to provide a better visual of the sample shunt. The prototype was designed at a 0.5 scale. PVC was chosen to make the prototype due to the ready availability of materials, sizes, shapes, and ease of construction. A 45^o wye pipeline and a 90^o pipe section were selected.

Figure 6. 45^o wye pipe section.

The 45^o wye pipe section provides the necessary angle to collect material from the flow path, Figure 6. A tee pipe section, with 90o angles, would not allow the material flow to maintain steady flow and minimal interference. The 90^o section was used to direct the collected sample into a container.

A 6 gauge sheet of aluminum was selected to construct the collector. The collector is a cylindrical shape formed around the inside of the 45^o branch. The one end of the cylinder is trimmed to match the curvature of the

45° inner branch. Therefore when the collector is disengaged the collector does not interfere with the flow. The length of the collector is cut just before the flange to refrain from contacting the 90° connection. The collector has a bolt through the side, which passes through the pipe and leaves the bolt head exposed to the flow.

The bolt acts as a lever for engaging and disengaging the collector. The pipeline has a 2.5 inch long cut that provides the path for engaging the collector. The lever's initial position is the disengaged position of the collector. The lever's furthest position from the initial places the collector at maximum depth, Figure 7.

Figure 7. Collector movement lever.

The 90° angle attachment pipe provides path for the sample to be directed downward. The end of this pipe exposes the sample to air and the environment. As the cement passes into this point the material will cause dusting in the surrounding area. To reduce the amount of dusting a rubber boot was attached to the end of pipe. A quarter inch thick rubber sheet was cut to fit inside the 90° pipe's flange. A clip was bolted on to the rubber to shape the rubber into a cylinder. The rubber was then bolted to the flanges. To provide flexibility of the rubber 0.75 inch slits were cut into the end of the boot. Figure 8 shows the 90° pipe with the boot attached. The prototype requires a cap to maintain pressure during operation. The final prototype is shown in Figure 9 and 10.

Figure 8. 90° Attachment and boot.

Figure 9. Aerial view of the prototype.

Figure 10. Side view of the prototype.

Testing

After prototyping completion, the device was checked for loose connections and attachments. The device was taken to a quality control laboratory for testing. A small sample of cement, slag, and fly ash were used as three separate tests for the device. Fly ash is byproduct of coal combustion which is recovered for use in concrete. This product is finely ground into microscopic spheres. This shape gives the product flow characteristics that resemble water. To illustrate best possible flow, the fly ash material was used. The initial design was based on cement which acts as the standard for the tests. Slag, also known as ground granulated blast furnace slag (GGBFS), is a fine material obtained from the manufacturing of pig iron. This product is currently used in concrete as a partial replacement of cement. The flow characteristics of slag are similar to that of cement.

The test consists of the device, the three test materials, flexible pipe, and a small portable vacuum system. The test materials were stored in a sealed container with a flexible hose connection to the wye pipe section. The opposite of this section is connected to the vacuum and the wye leads to another container.

Each material was placed in the sealed container and start up the vacuum system. To retain pressure in the system the wye must have a cap covering the sample pipe section. Once material flow begins the cap is removed and sampling can commence.

Results

The performance criteria for each of the materials were ease of operation, collector durability, resistance to operate, and flow interruption. Flow speed was not a necessary factor of the performance test. Ease of operation, A, refers to the ability to use the device during operation of the collector. The resistance to operate, C, refers to clogging and interference flow path of the sample. Collector durability, B, refers to resisting wear on the interior of the device and the collector. Flow interruption, D, refers to the amount of disturbance in the main flow created by the collector. Each criterion was judged on a scale of 1 to 5 with 5 being the best. Each test material increased or decreased the chance of performance problems occurring in particular areas. After using each material the device was cleansed using compressed air. This allows for individual analysis of the device after each material.

The fly ash material had the best overall performance. The table below illustrates the device's performance with the three materials, Table 1.

	A	B	C	D	Total
Fly Ash	5	5	5	4	19
Cement	4	4	4	3	15
Slag	3	3	4	3	13

Table 1. Test material results.

The above results show that the fly ash performed best as expected. The cement and slag were mediocre in overall performance but the cement did perform well with collector durability and operation resistance factors. The fly ash did cause minor flow disturbance but the disturbance was not as noticeable as the cement and slag. Operating the collector was easily done for each of the materials but build up along the branch began to create minor problems for cement and slag. The device's performance with cement and slag was considerably better than expected compared to the fly ash. The cement, slag, and fly ash materials are easier to handle with this device. A full scale prototype will be developed in the near future with minor adjustments to the design. The boot will be reduced in diameter and placed inside of a PVC pipe section, which will allow easier cap removal. Also, slots will be cut into the collector lever engagement path for easier depth selection.

References

http://www.olstaco.com/

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Acknowledgements

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